Can Linear Light Sources Be Beneficial to Pilots?

John D. Bullough, Ph.D. and Nicholas P. Skinner, M.S.
Lighting Research Center, Rensselaer Polytechnic Institute

2014 FAA Worldwide Airport Technology Transfer Conference
Galloway, NJ – August 5-7, 2014

Lighting Research Center

Rensselaer

LRC and Aviation Lighting Research

Aviation Lighting Research at the LRC

Human Factors

Color Vision Status and LED Identification
Signal Light Brightness
Perception of Linear Lighting
Effective Intensity of Flashing Lights
Stroboscopic Effect Perception
Requirements for LED Runway Guard Lights
Specifications for Remote Airfield Lighting

Solid State Lighting Technology

Heat Transfer in Taxiway Edge Lights
Life Testing for Airfield Lighting Fixtures
Solar-Powered LED Fixtures
Volatile Organic Compound Effects in LEDs
LED Driving Circuitry and Flicker
Photometric Testing for LED Fixtures
Electrical Infrastructure Research Team Support
Phosphor-Converted Amber LEDs
Junction Temperature Estimation for AC LEDs
LED Electrical and Thermal Parameters Under Stress

Study Objective

- To identify whether linear configurations of runway/taxiway edge lighting systems offer benefits over conventional practices using discrete “point” sources of light
- Series of experiments from static screen-based, to dynamic screen-based, to static full-scale investigations

(Gallagher 2005)

Representative Delineation Practices

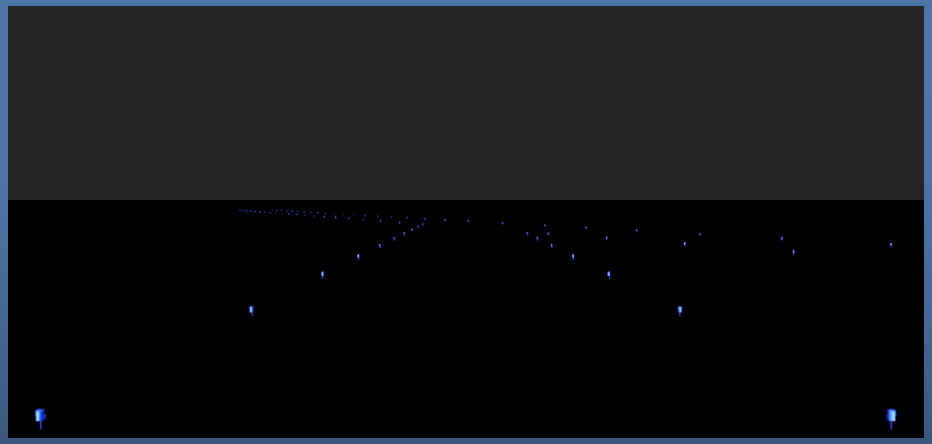
Representative edge and centerline practices for airfield lighting.

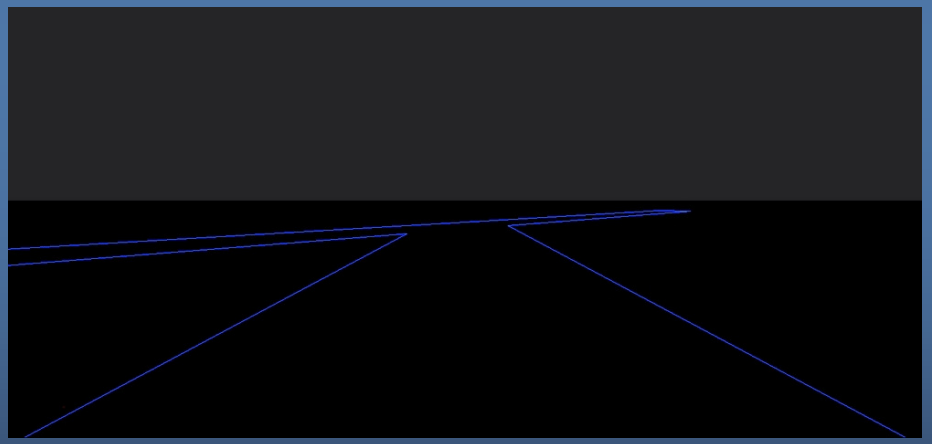
Application	Condition	Minimum Spacing (ft)*
Runway Edge Lighting	General	200 ft
Runway Centerline Lighting	General	50 ft
Taxiway Edge Lighting	Short Section	50 ft
	Intermediate Section	100 ft
	Long Section	200 ft
Taxiway Centerline Lighting†	Very Tight Curved Section	25 ft
	Tight Curved Section	50 ft
	Wide Curved Section	100 ft
	Straight Section	200 ft

*Special situations (e.g., very complex geometries) may require shorter spacing.
†Spacing should be halved when airfield is used under low-visibility conditions.

Experiment 1

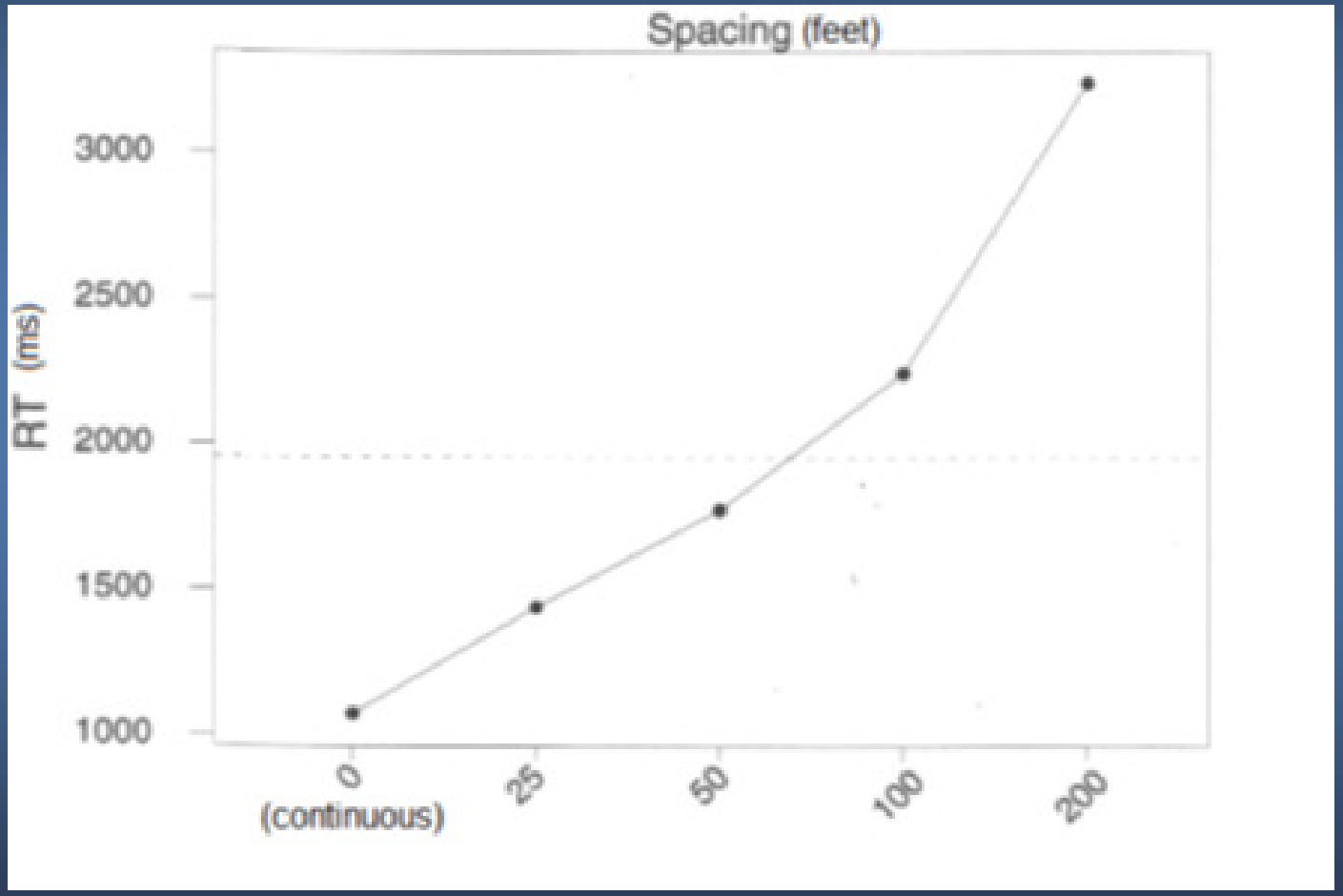
- Compare point source edge light fixture spacing of 25, 50, 100, 200 ft to continuous edge delineation (blue)
- Subjects identified cross, tee, skew left/right geometry
- Simulated view from 575 feet away, 20 feet high





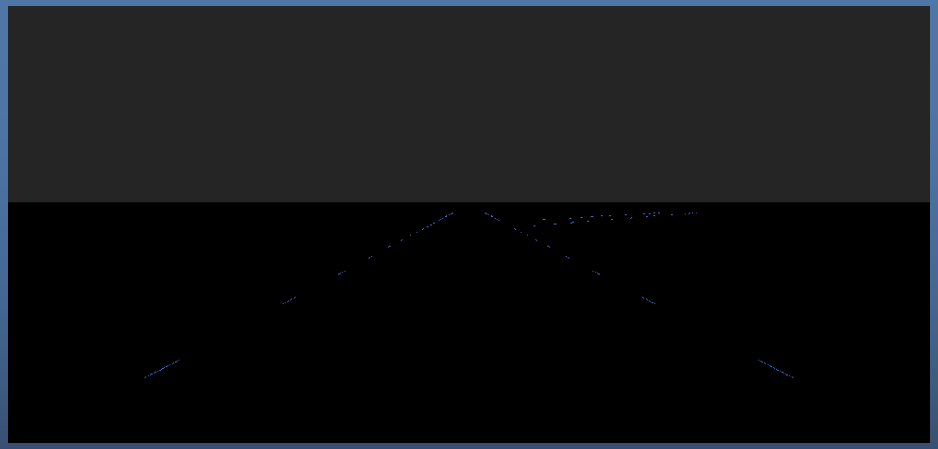
Primary performance measure:
Intersection configuration identification times

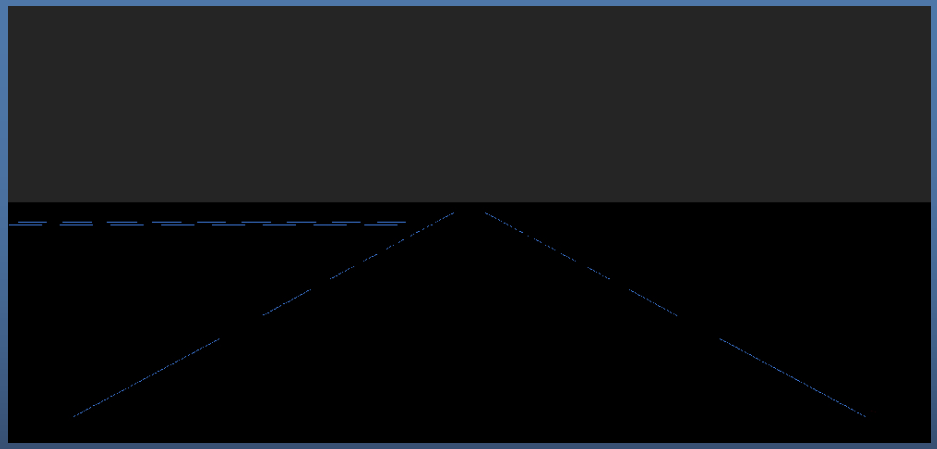
Experiment 1 Results



Experiment 2

- Right/left, 90°/30° angle
- 2, 8, 32 ft element length
- 50, 100, 200 ft spacing
- Edge lighting (all blue)

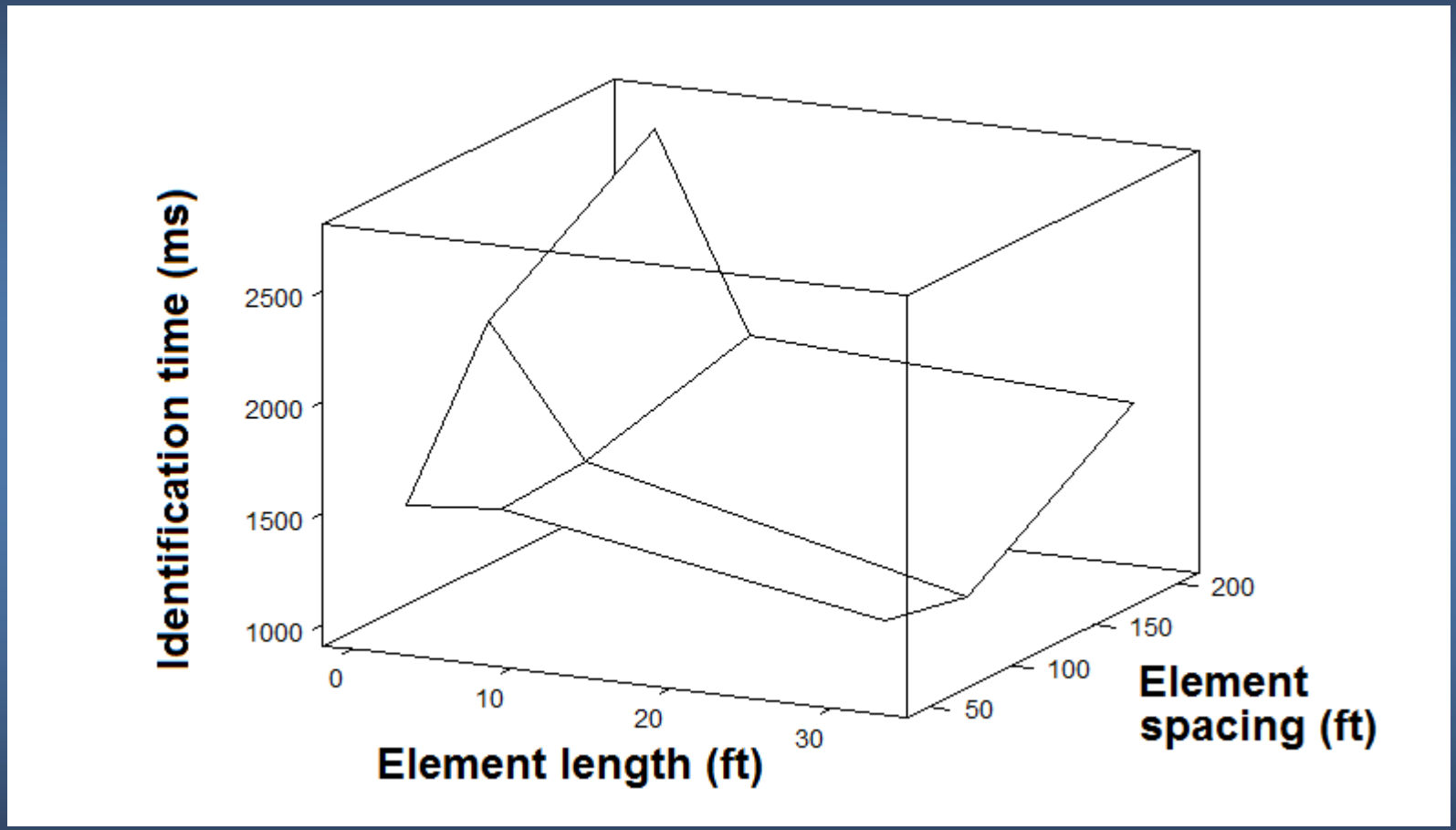




Lighting Research Center

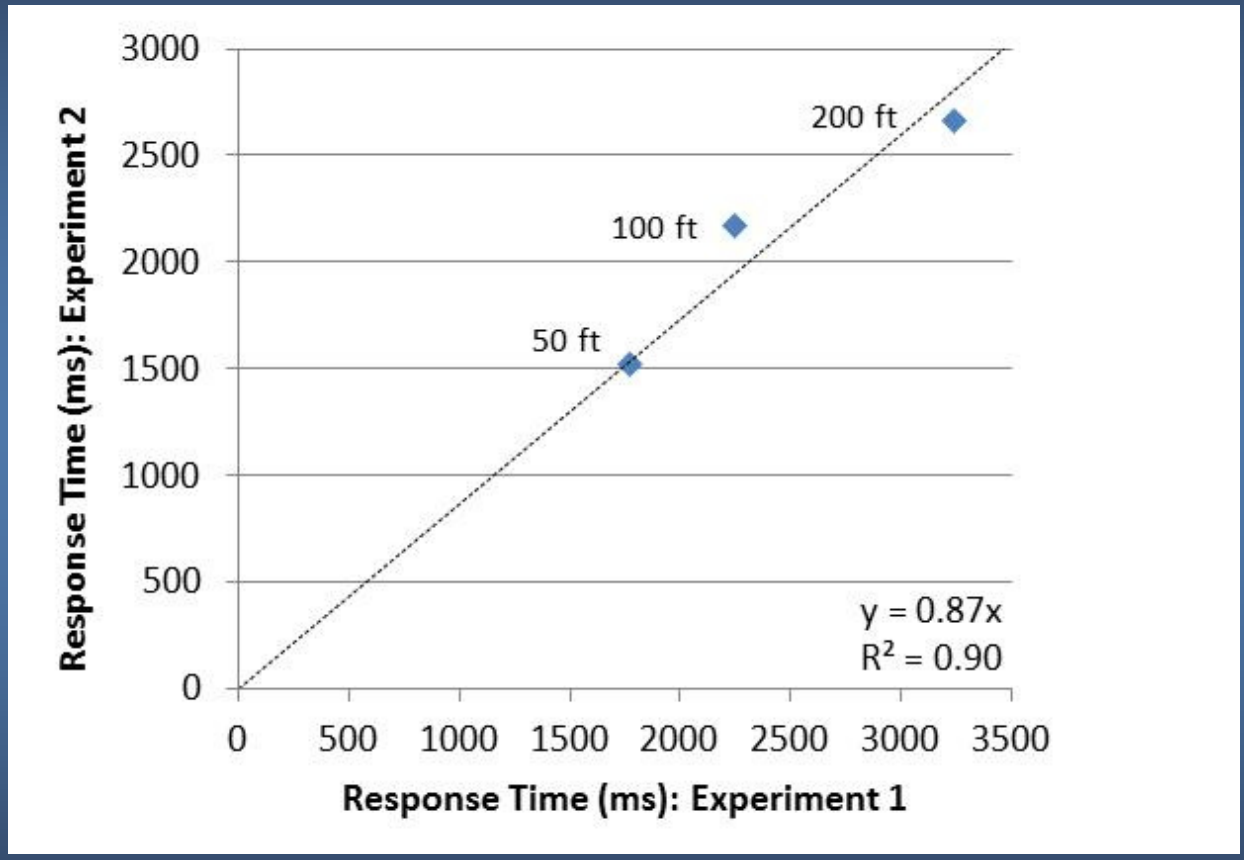
Rensselaer

Experiment 2 Results



RT (ms) = 286 – 607 log *L* + 989 log *S*

Comparison Between Point Edge Light and 2-ft Element Length



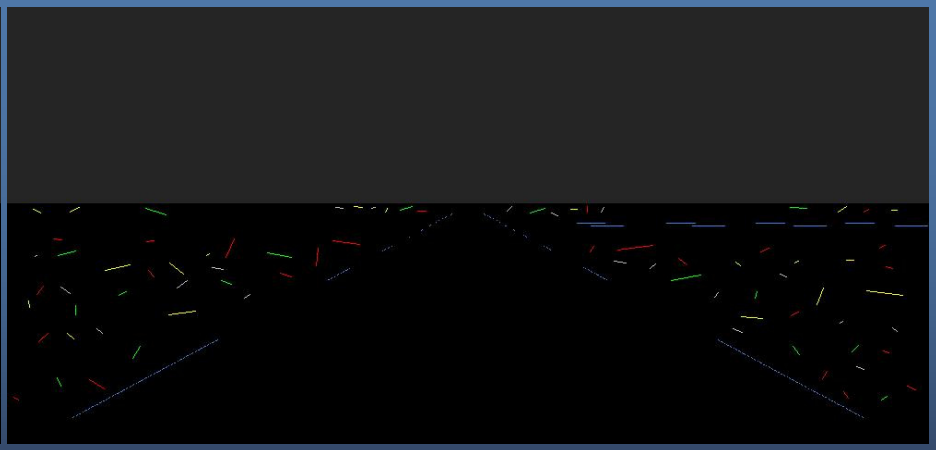
Data suggest there is little benefit to a linear element length of 2 ft over a point source size when matched for spacing, for the conditions tested

Lighting Research Center

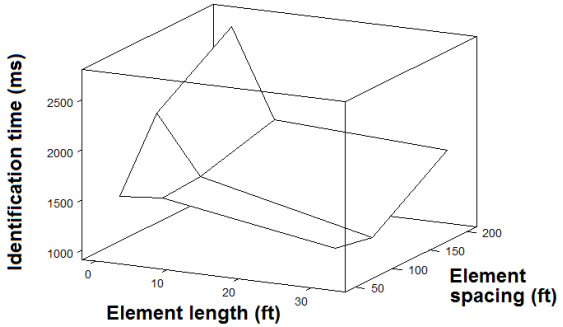
Rensselaer

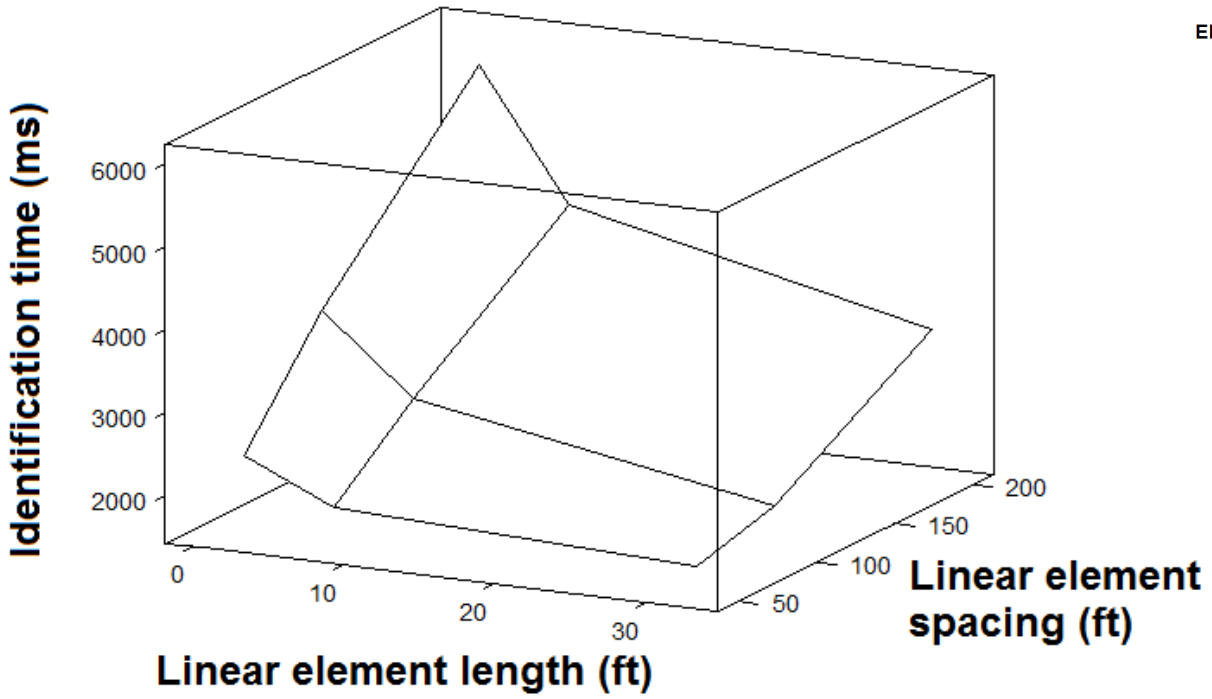
Experiment 3

- Right/left, 90°/30° angle
- 2, 8, 32 ft element length
- Edge lighting (all blue)
- 50, 100, 200 ft spacing
- Visual noise present (multicolored)



Experiment 3 Results





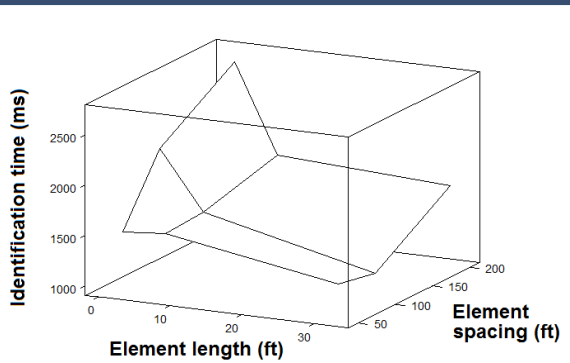
Values with visual noise were strongly correlated (r^2=0.86) to those without

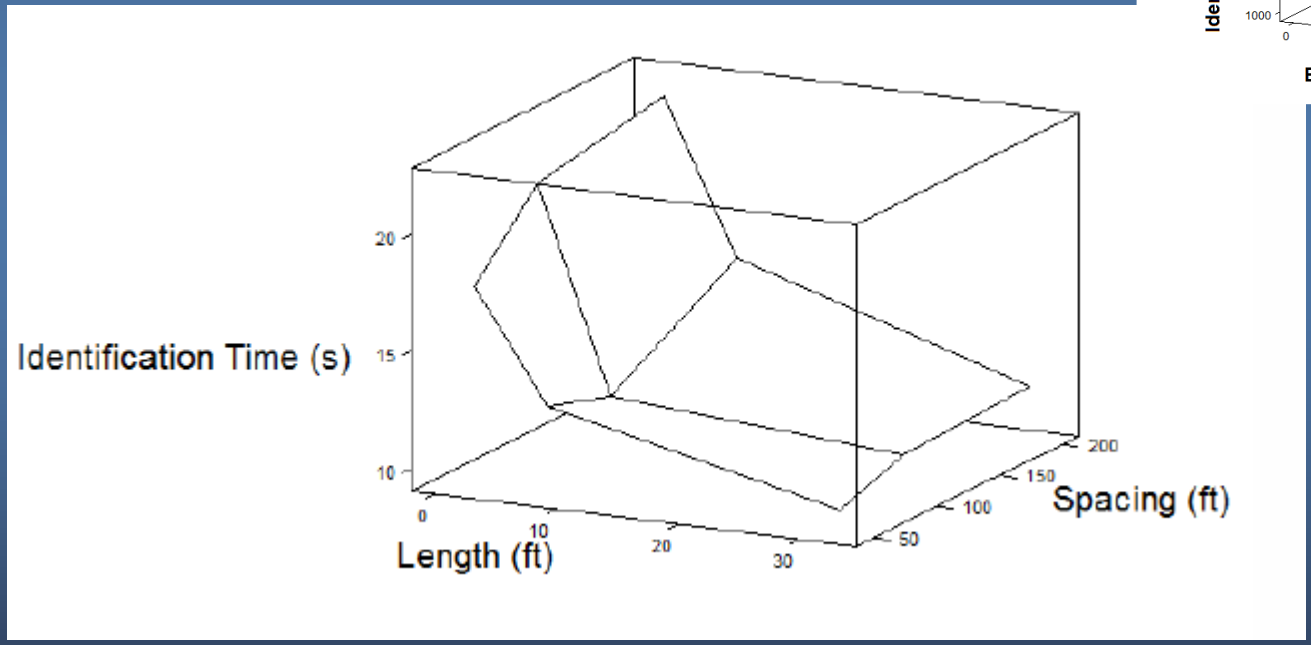
Factor: 1.8x

Experiments 4 and 5

- Dynamic animation starting from 2000 ft away, 50 mph
- 30^{o}/90^{o} left/right taxiway from runway
- Centerline delineation (white/runway, green/taxiway)
- 2, 8 or 32 ft element length; 50, 100, 200 ft spacing
- Intensity reduced by factor of 4× for Experiment 5

Experiment 4 Results





Correlated (r^2=0.73) to Experiment 2 results

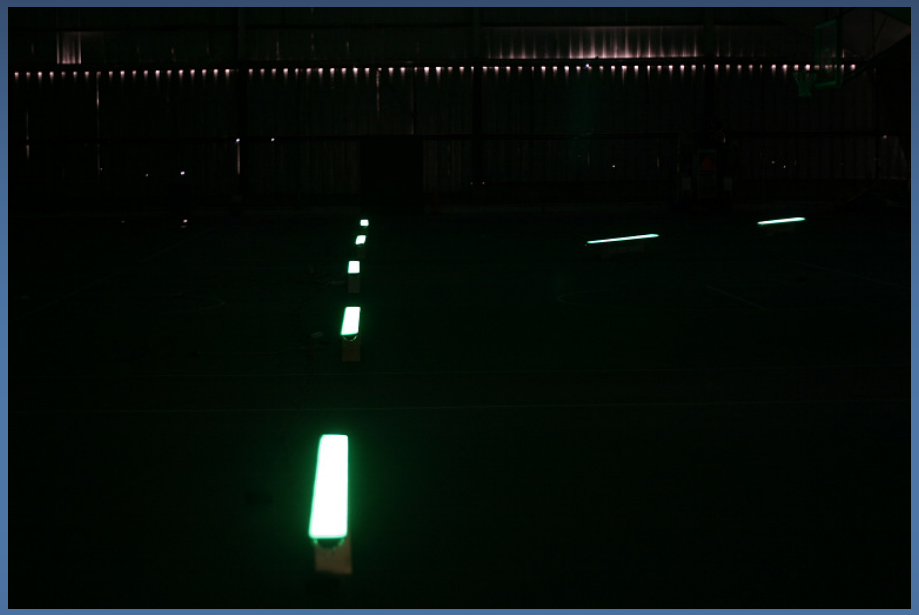
Factor: 8.6x

Nearly identical results for Experiment 5

Lighting Research Center

Rensselaer

Experiment 6

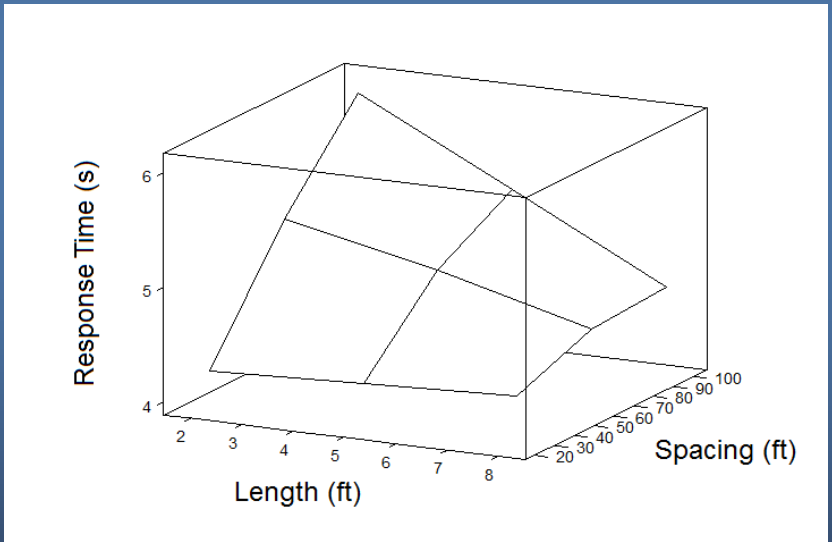


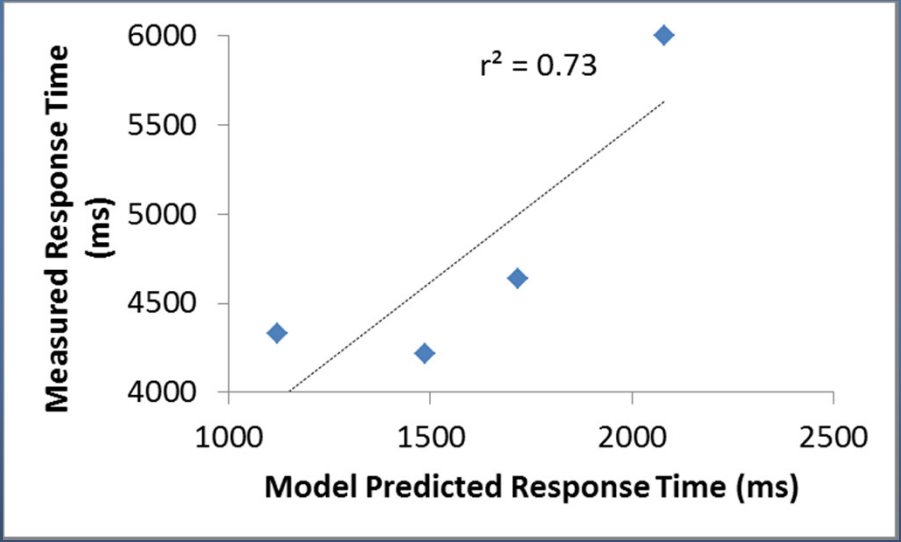
LED lights were located to represent centerlines along an intersection (shown: right side, 30° angle)

Participants viewed scenes through the window (with room lights off) and recorded their responses on a laptop computer

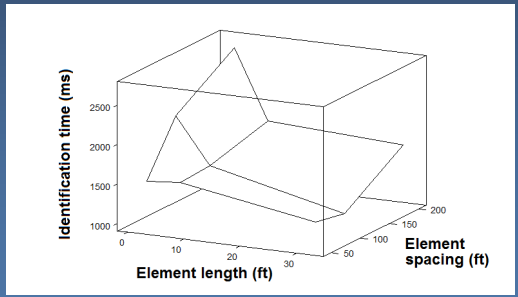
Experiment 6 Results

- Present data are consistent with model predictions based on laboratory study data





Discussion: Trading Off Length and Spacing



RT (ms) = 286 – 607 log *L* + 989 log *S*

Combinations of delineation element length and spacing to achieve the same relative response times expected from 2-ft-long delineation elements spaced at 50 and 100 ft.

Base Case 1	Element length	2 ft	**6.2 ft**	**12.0 ft**	**19.2 ft**
	Element spacing	50 ft	100 ft	150 ft	200 ft
	Relative response time	1784 ms	1784 ms	1784 ms	1784 ms
Base Case 2	Element length		2 ft	**3.9 ft**	**6.2 ft**
	Element spacing		100 ft	150 ft	200 ft
	Relative response time		2081 ms	2081 ms	2081 ms

Conclusions

- Data for varied edge/centerline configurations differing in color and in movement (static vs. dynamic) were highly consistent
- Results could provide basis for quantitatively trading off linear element length and spacing for various configurations
- Field validation will be necessary and is underway by FAA

Thank You!

- Federal Aviation Adminsitration (Contract 2010-G-013)
- Donald Gallagher, Project Manager
- Robert Booker, FAA
- Mayor Michael Manning and Recreation Supervisor Robert Loya, City of Watervliet